

Figure 15. Level Detector with Hysteresis

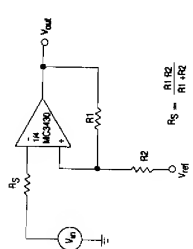


Figure 16. Transfer Characteristics and Equations for Figure 15

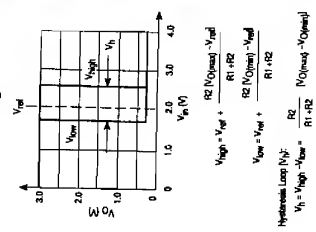


Figure 17. Double-Ended Limit Detector

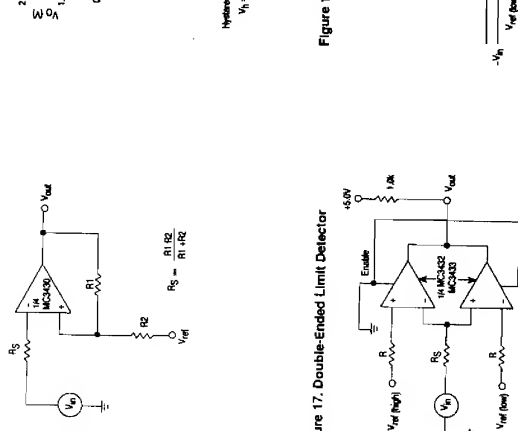


Figure 18. Voltage Transfer Function

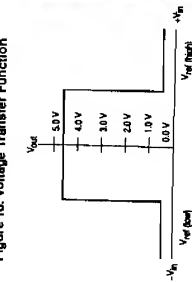


Figure 19. Level Detector with Hysteresis

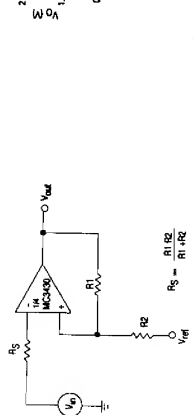


Figure 20. Transfer Characteristics and Equations for Figure 19

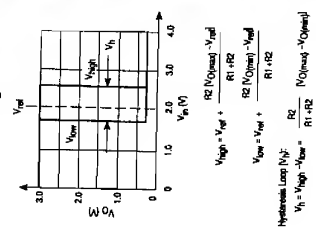


Figure 21. Double-Ended Limit Detector

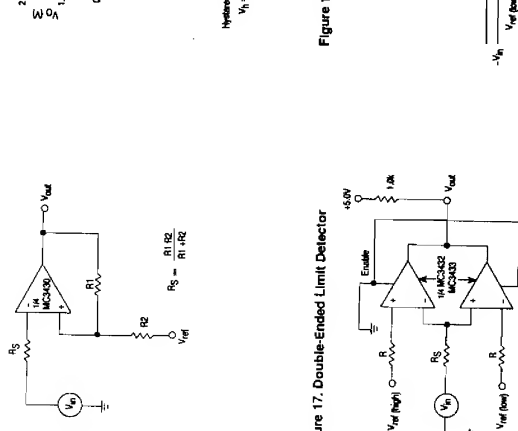
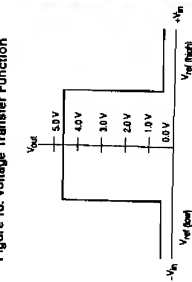


Figure 22. Voltage Transfer Function



MC3458  
MC3558  
MC3558

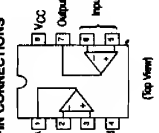
DUAL DIFFERENTIAL  
INPUT  
OPERATIONAL AMPLIFIERS  
SILICON MONOLITHIC  
INTEGRATED CIRCUIT

P<sub>1</sub> SUPPLY  
PLASTIC PACKAGE  
CASE 625

U SUPPLY  
CERAMIC PACKAGE  
CASE 693

D SUPPLY  
PLASTIC PACKAGE  
CASE 751  
(SO-8)

PIN CONNECTIONS



ORDERING INFORMATION

Device	Temperature Range	Package
MC3558P1	-40° to +85°C	Plastic DIP
MC3458D	0° to +70°C	SO-8
MC3558D1	0° to +70°C	Plastic DIP
MC3458U	-55° to +125°C	Ceramic DIP
MC3558U	-55° to +125°C	Ceramic DIP

**ELECTRICAL CHARACTERISTICS** (For MC3558,  $V_{CC} = +15V$ ,  $V_{EE} = -15V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.)  
(For MC3358,  $V_{CC} = +14V$ ,  $V_{EE} = -14V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
Input Offset Voltage $T_A = T_{ref} \pm 10^\circ C$ (Note 1)	$V_{IO}$	—	2.0	6.0	—	2.0	10	—	2.0	6.0
Input Offset Current $T_A = T_{ref} \pm 10^\circ C$	$I_{IO}$	—	30	50	—	30	100	—	30	75
Input Bias Current $V_{IO} = +15V$ , $R_{in} = 2.0 k\Omega$	$I_{BIAS}$	—	200	250	—	30	200	—	250	300
Large Signal Open-Loop Voltage Gain $V_{IO} = +15V$ , $R_{in} = 2.0 k\Omega$	$A_{VOL}$	50	200	—	20	200	—	20	200	—
$T_A = T_{ref} \pm 10^\circ C$		25	300	—	15	—	—	—	—	—
Input Common-Mode Voltage Range $T_A = T_{ref} \pm 10^\circ C$	$V_{ICM}$	—	—	—	—	—	—	—	—	—
Input Impedance $f = 20 Hz$	$Z_i$	—	75	—	—	75	—	—	75	—
Output Voltage Range $R_L = 10 k\Omega$ $R_L = 2.0 k\Omega$ , $T_A = T_{ref} \pm 10^\circ C$	$V_{OH}$	112	$\pm 13.5$	—	112	$\pm 13.5$	—	112	$\pm 13.5$	—
Input Common-Mode Voltage Range $T_A = T_{ref} \pm 10^\circ C$	$V_{ICM}$	—	—	—	—	—	—	—	—	—
Common-Mode Rejection Ratio $R_{in} = 10 k\Omega$	$CMR$	70	90	—	70	90	—	70	90	—
Power Supply Current ( $N_Q = 0$ ) $T_A = T_{ref} \pm 10^\circ C$	$I_{CC}$	—	1.8	2.2	—	1.6	3.7	—	1.6	3.7
Internal Output Short-Circuit Current (Note 2)	$I_{SC}$	110	250	445	110	250	445	110	250	445
Positive Power Supply Rejection Ratio	$PSRR_{+}$	—	30	150	—	30	150	—	30	150
Negative Power Supply Rejection Ratio	$PSRR_{-}$	—	30	150	—	30	150	—	30	150
Amplifier Input Bias Current $T_A = T_{ref} \pm 10^\circ C$	$I_{BIAS}$	—	50	—	—	50	—	—	50	—
Amplifier Input Impedance $T_A = T_{ref} \pm 10^\circ C$	$Z_{in}$	—	10	—	—	10	—	—	10	—
Power Bandwidth $T_A = T_{ref} \pm 10^\circ C$	$BW$	—	9.0	—	—	9.0	—	—	9.0	—
Small Signal Bandwidth $A_v = 1$ , $R_L = 10 k\Omega$ , $V_{IO} = 50 mV$	$BW$	—	1.0	—	—	1.0	—	—	1.0	—
Slew Rate $A_v = 1$ , $R_L = 10 k\Omega$ , $V_{IO} = 10 V$	$SR$	—	0.6	—	—	0.6	—	—	0.6	—
Rise Time $A_v = 1$ , $R_L = 10 k\Omega$ , $V_{IO} = 50 mV$	$T_{RI}$	—	0.35	—	—	0.35	—	—	0.35	—
Fall Time $A_v = 1$ , $R_L = 10 k\Omega$ , $V_{IO} = 50 mV$	$T_{FI}$	—	0.35	—	—	0.35	—	—	0.35	—
Overload $A_v = 1$ , $R_L = 10 k\Omega$ , $V_{IO} = 50 mV$	$OS$	—	20	—	—	20	—	—	20	—
Phase Margin $A_v = 1$ , $R_L = 10 k\Omega$ , $V_{IO} = 50 mV$	$\phi_m$	—	60	—	—	60	—	—	60	—
Common-Mode Rejection Ratio $R_{in} = 10 k\Omega$ , $V_{IO} = 50 mV$	$CMR$	—	1.0	—	—	1.0	—	—	1.0	—

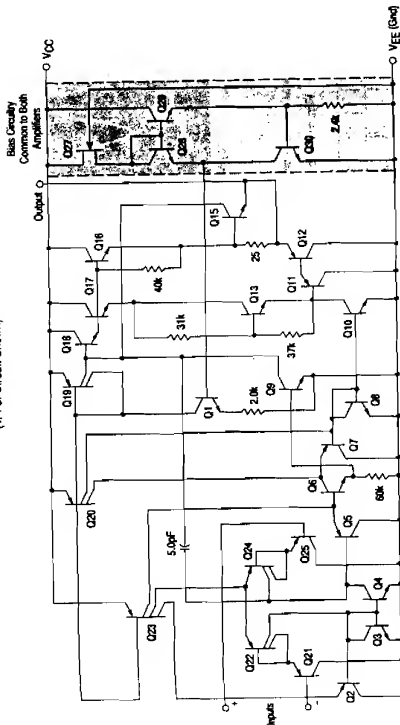
NOTES: 1.  $T_{ref} = 25^\circ C$  for MC3458,  $25^\circ C$  for MC3558,  $25^\circ C$  for MC3358.  
2.  $I_{SC}$  is limited by maximum junction temperature.

**ELECTRICAL CHARACTERISTICS** ( $V_{CC} = 5.0V$ ,  $V_{EE} = -5.0V$ ,  $T_A = 25^\circ C$ , unless otherwise noted.)

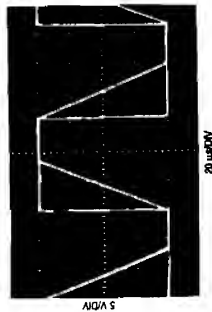
Characteristics	Symbol	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
Input Offset Voltage	$V_{IO}$	—	2.0	5.0	—	2.0	5.0	—	2.0	10
Input Offset Current	$I_{IO}$	—	30	50	—	30	50	—	30	75
Input Bias Current	$I_{BIAS}$	—	200	250	—	200	250	—	200	250
Large Signal Open-Loop Voltage Gain	$A_{VOL}$	—	200	—	—	200	—	—	200	—
Power Supply Rejection Ratio	$PSRR$	—	150	—	—	150	—	—	150	—
Output Voltage Range (Note 3)	$V_{OH}$	3.3	3.5	—	3.3	3.5	—	3.3	3.5	—
Input Common-Mode Voltage Range $R_L = 10 k\Omega$ , $V_{IO} = 50 mV$	$V_{ICM}$	—	—	—	—	—	—	—	—	—
Common-Mode Rejection Ratio	$CMR$	—	1.0	—	—	1.0	—	—	1.0	—

NOTES: 3. Output will swing to ground with a 10 k $\Omega$  load down resistor.

Representative Circuit Schematic  
(1/4 of Circuit Shown)



Inverter Pulse Response



# CIRCUIT DESCRIPTION

The MC3558 Series is made using two internally compensated, two-stage operational amplifiers. The first stage of each consists of differential input devices Q24 and Q22 with input buffer transistors Q25 and Q21 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shift and transconductance reduction functions. By reducing the transconductance a smaller compensation capacitor is required, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q24 and Q22. Another feature of this input stage is that the input Common Mode range can include the negative supply or ground, in single ended operation, without saturating either the input devices or the differential to single-ended converter. The second stage consists of a standard current source load amplifier stage.

The output stage is unique because it allows the output to swing to ground in single supply operation and yet does not exhibit any crossover distortion in split supply operation. This is possible because Class AB operation is utilized.

Each amplifier is biased from an internal voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

Figure 1. Sine Wave Response

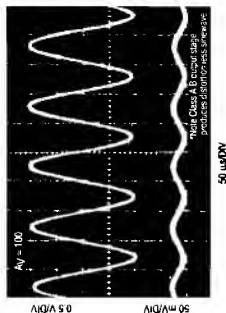


Figure 2. Open-Loop Frequency Response

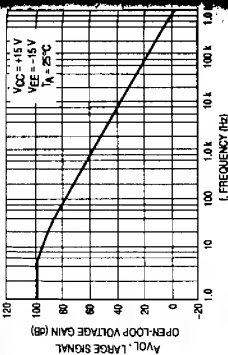


Figure 3. Power Bandwidth

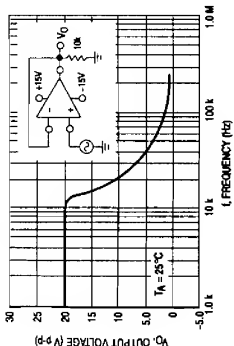


Figure 4. Output Swing versus Supply Voltage

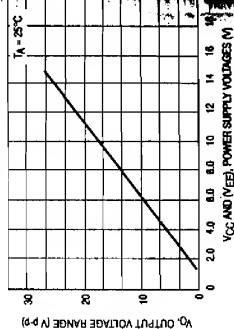


Figure 5. Input Bias Current versus Temperature

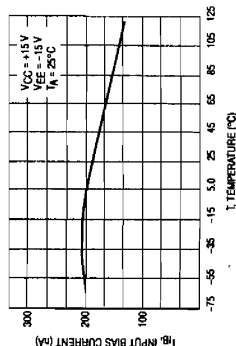


Figure 6. Input Bias Current versus Supply Voltage

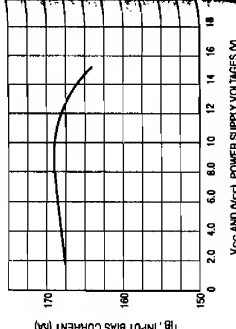


Figure 7. Voltage Reference

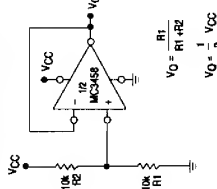


Figure 8. Wien Bridge Oscillator

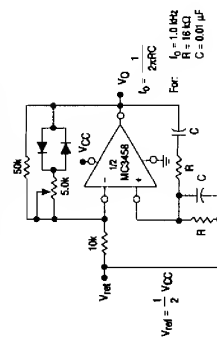


Figure 9. High Impedance Differential Amplifier

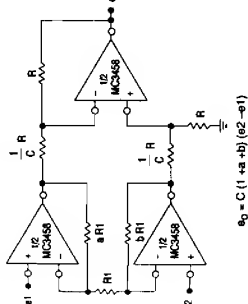


Figure 10. Comparator with Hysteresis

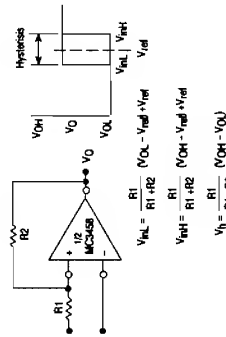


Figure 11. Filter

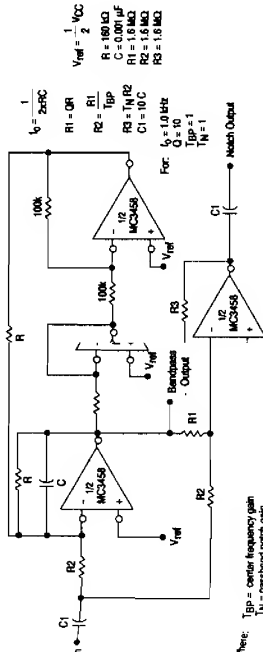
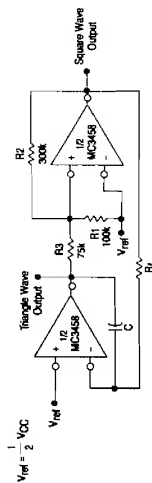
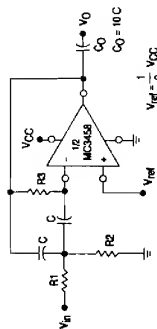


Figure 12. Function Generator



$$f = \frac{1}{4CR_1} \quad R_1 = R_2 \quad R_2 = R_1$$

Figure 13. Multiple Feedback Bandpass Filter



Given:  $f_0$  = center frequency

$A(f_0)$  = gain at center frequency

Choose value  $f_0$ , C.

$$\text{Then: } R_3 = \frac{Q}{\pi f_0 C} \quad R_1 = \frac{R_3}{2A(f_0)} \quad R_2 = \frac{R_1 R_3}{4Q^2 R_1 - R_3}$$

For less than 10% error from operational amplifier

where,  $f_0$  and BW are expressed in Hz.

If source impedance varies, filter may be preceded with

voltage follower buffer to stabilize filter parameters.

## MOTOROLA SEMICONDUCTOR TECHNICAL DATA

MC3476

### Low Cost Programmable Operational Amplifier

The MC3476 is a low cost selection of the popular, industry standard MC1776 programmable operational amplifier. This extremely versatile operational amplifier features low power consumption and high input impedance. In addition, the quiescent currents within the device may be programmed by the choice of an internal resistor value or current source applied to the  $I_{SET}$  input. This allows the amplifier's characteristics to be optimized for input current and power consumption despite wide variations in operating power supply voltages.

- $\pm 6.0$  V to  $\pm 18$  V Operation
- Wide Programming Range
- Offset Null Capability
- No Frequency Compensation Required
- Low Input Bias Currents
- Short Circuit Protection

P1 SUFFIX  
PLASTIC PACKAGE  
CASE 826U SUFFIX  
CERAMIC PACKAGE  
CASE 685

#### Relative Programming (See Figure 1)

##### Reset to Ground

$I_{SET} = 1.5 \mu A$

$I_{SET} = 1.5 \mu A$

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$I_{SET} = 1.5 \mu A$

$I_{SET} = 1.5 \mu A$

Typical Reset Values			
VCC - VEE	$I_{SET}$	$R_{SET}$	$I_{SET}$
$\pm 15$ V	1.5 $\mu A$	100 k $\Omega$	1.5 $\mu A$
$\pm 12$ V	1.5 $\mu A$	100 k $\Omega$	1.5 $\mu A$
$\pm 9$ V	1.5 $\mu A$	100 k $\Omega$	1.5 $\mu A$
$\pm 6$ V	1.5 $\mu A$	100 k $\Omega$	1.5 $\mu A$
$\pm 3$ V	1.5 $\mu A$	100 k $\Omega$	1.5 $\mu A$

#### Active Programming

##### Bipolar Current Source



Pin 9 not shown are not connected.

#### ORDERING INFORMATION

Device	Temperature Range	Package
MC3476P1	0° to +70°C	Plastic DIP
MC3476U		Ceramic DIP